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Strengthening Lead by Reinforcement with Molybdenum Wires

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Lead has a high density, very good self-lubrication characteristics and outstanding resistance to chemical corrosion—properties which make it suitable for a wide variety of industrial applications. As a corrosion-resistant material, for example, it is still employed extensively in the chemical industry; its high density is exploited in such uses as radioactivity shielding and sound attenuation; and its lubrication characteristics find an outlet in bearing applications. But its suitability for these, or indeed any other, applications is dependent upon a single critical factor: its poor mechanical properties. In other words, specify even moderate strength and creep-resistance in addition to corrosion-resistance and/or high density, and the metal becomes ineligible. Hence any economic method of raising its strength without sacrificing its other properties would obviously greatly increase its usefulness. One approach is fibre reinforcement—to incorporate into the lead a uniform dispersion of very thin, but very strong, fibres or wires, with the aim of strengthening the matrix. Using this approach, the Atomic Weapons Research Establishment has succeeded in considerably increasing the metal's mechanical properties.

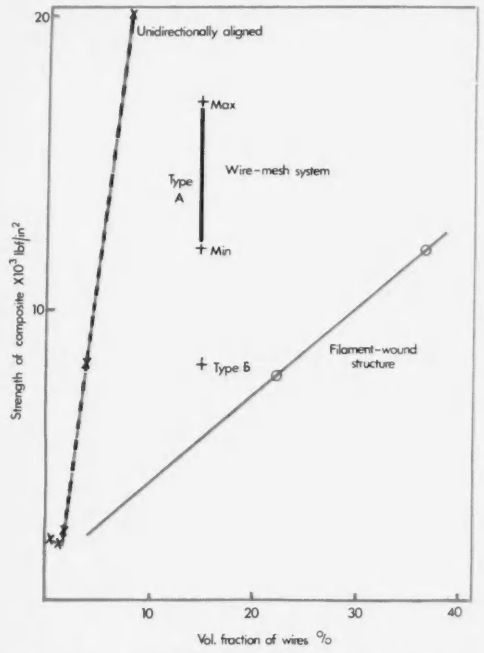
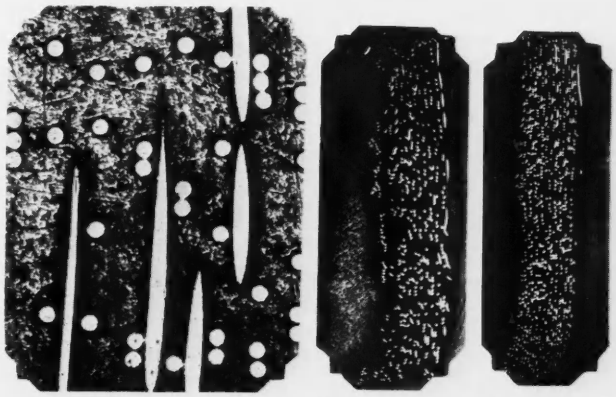


Figure 1. Strength of lead/wire composites v *wire content for various wire configurations.*



Wire-reinforced composites prepared by filament winding and centrifugal casting. Left: 21.5 vol % (× 40). Centre: 21.5 vol % (× 6). Right: 30 vol % (× 6).

Molybdenum wires were adopted as the reinforcement material, as being representative of the types of fibre available. AWRE explored three procedures for dispersing the wires throughout the lead: (1) vacuum infiltration of liquid lead into parallel bundles of molybdenum wires; (2) centrifugal casting of lead into a filament-wound molybdenum framework, producing fibre-reinforced lead pipe; and (3) rolling molybdenum wire mesh into lead sheets and then compacting the sheets together under conditions in which the lead was molten (ie, liquid-phase hot pressing). The first procedure resulted in unidirectional reinforcement (ie, in the axial direction of the molybdenum wires); the other two achieved two-dimensional reinforcement. All three types of composite were subjected to tensile tests. The strength/wire-volume-fraction relationships derived are plotted in Figure 1.

The undirectionally reinforced composites (ie, those produced by procedure 1) contained up to 0.08 volume fractions of molybdenum wire. At the 0.08 volume fraction, reinforcement raised the tensile strength to as high as 22.10^3 lbf/in² (154 MNm^{-2})—ten times that of unreinforced lead. Reinforcement also greatly increased creep-resistance, and a composite with a 0.08 volume fraction of wire withstood a constant stress of 10.10^3 lbf/in² (70 MNm^{-2}) for 36 months with no measurable extension. These results imply that fibre strength was being utilised to 100 per cent efficiency.

The filament-wound/centrifugally-cast composites contained up to 0.40 volume fractions of wire, and specimens for tensile testing were cut from the shell of the centrifugal casting. The tensile data presented in Figure 1 were derived from composites produced using uncoated molybdenum wires for the filament-winding, but more recent tests have shown that higher strengths—17.10^3 lbf/in² (119 MNm^{-2}) at 0.30 fibre volume fraction—can be achieved by plating the reinforcement wire with lead before use, to promote adhesion

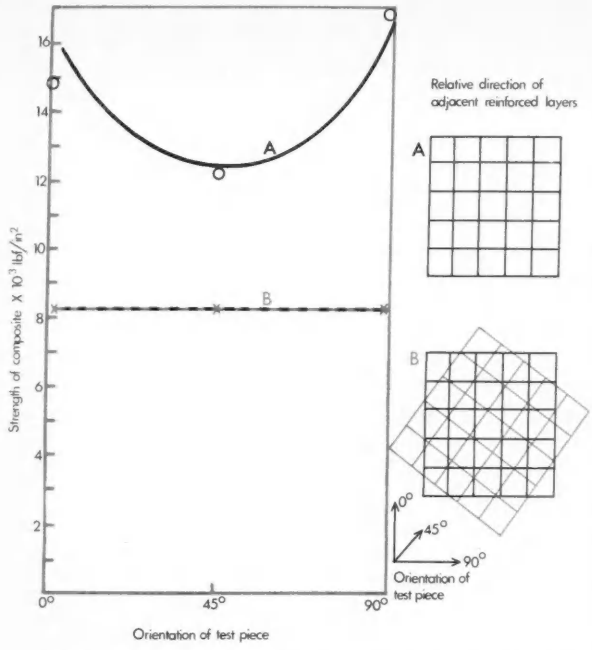


Figure 2. Directional properties of lead/wire-mesh composites tested in uniaxial tension.

between the reinforcement and the matrix. In both cases, however, reinforcement efficiency with this type of composite is very low: 25 per cent for unplated wire and 35 per cent for plated wire.

In contrast, efficiencies of more than 80 per cent were obtained from composites made by liquid-phase hot pressing together lead sheets into which molybdenum wire mesh had been previously rolled. In evaluating this type of composite, AWRE gave some consideration to the influence of mesh orientation on tensile properties: in one series of tests, adjacent mesh reinforcements were oriented in the same direction (see drawing A in Figure 2); in another, the adjacent mesh layers were given different relative orientations (see drawing B in Figure 2). Coupons for tensile testing were cut from the composites in three directions: at angles of 0°, 45° and 90° (see Figure 2). At a wire volume fraction of 0.15, the type A composite exhibited a maximum tensile strength of 16.10^3 lbf/in² (112 MNm^{-2}), and its strength was lowest (12.10^3 lbf/in²: 84 MNm^{-2}) in the 45° direction—ie, that in which none of the wires was aligned in the stress direction. In contrast, the tensile properties of the type B composite did not vary with the direction in which the test coupon was taken, and all the specimens exhibited a tensile strength of 8.10^3 lbf/in² (56 MNm^{-2}). The difference in properties between types A and B is hence attributable to the relative orientations of the reinforcing meshes. Hence, by using an appropriate mixture of mesh orientations, mesh-reinforced lead can be made to exhibit uniform properties in all directions—though admittedly at some sacrifice in strength compared with the maximum exhibited by unidirectionally reinforced composites. AWRE has also found that mesh-reinforced composites can be formed into a variety of shapes.

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WSL and mineral processing at sea

As world demand for minerals continues to increase it will become necessary to consider the exploitation of all known mineral resources, including, in the United Kingdom, those of the Continental Shelf. Off-shore mining is a well-established activity in the petroleum and sand and gravel industries, and coal has been won off-shore for many years, but the technology of off-shore mining of alluvial minerals and their processing afloat is still in its infancy. Obviously no company will embark on an off-shore mining operation unless reasonably sure that the mineral won from the sea-bed can be marketed competitively with that won on land. If off-shore mineral deposits are to be fully exploited, therefore, work will have to be undertaken to achieve maximum efficiency in every aspect of the mining and subsequent processing operations.

At present material dredged from the sea-bed would probably have to be transported ashore and stored to await processing. However, alluvial deposits are generally of low grade, and all but a small percentage of the material shipped ashore would be waste and would have to be disposed of. The head value of tin-sands, for example, is usually less than ½ per cent, so that more than 99½ per cent of the material shipped ashore is waste. Preconcentration of the dredged material on the dredger itself seems the obvious solution to this problem, but would such preconcentration operations be rendered impossible by the motion of the dredger on the open sea? DTI's Warren Spring Laboratory, which had already become involved in off-shore mining by conducting beneficiation tests for a company exploring tin-sands off Cornwall, decided to investigate this aspect by examining the performance of processing equipment installed on a test rig designed to simulate the motion of a dredger.

The limits of motion within which dredging is feasible were determined, and this information provided the basis for selecting the operating conditions of the test rig. The rig was capable of simulating angular motions of up to 25° of roll, 12° of pitch, and 5° of yaw. As the best alternative to a true 'heave' displacement, which would have entailed jacking up the rig platform to a considerable height, a cantilever design was adopted to simulate deck-edge heave, with the piece of equipment under test positioned at the end of the cantilever. Each item of equipment was first tested with the rig stationary, in order to establish the operating conditions for maximum efficiency, and then operated under these optimum conditions while the rig was subjected to the simulated dredger motion. In addition, equipment was tested in two orientations—in the axis of pitch and the axis of roll—in order to find out which would be the better direction for feed flow. So far various types of distributing and concentrating equipment have been evaluated on the rig, including a rotary pulp distributor, a cone distributor, a diamond splitter, a pinched sluice and a mineral jig. In general, the test results show that, under dredger motion, certain items of equipment designed for use in land-based plant decrease markedly in efficiency, and, as would be expected, the effects are particularly pronounced where the equipment is sensitive to fluid-flow fluctuations. The test results to date were fully reported in a paper which T. H. Hughes and A. S. Joy presented at the *Oceanology International '72 Conference* earlier this month.

The initial investigation referred to above now needs to be followed by a detailed programme of exploration using more sophisticated equipment. WSL is actively seeking industrial partners to share the costs of such an investigation, and also the potential rewards, in the form of novel and improved equipment design and/or improved processing efficiency.

More information: Mr. T. H. Hughes, Warren Spring Laboratory, Gunnels Wood Road, Stevenage, Herts. Tel: Stevenage 3388.

Engineering Sciences on Show at
NPL OPEN DAYS: May 9–11, 1972

Each year the National Physical Laboratory, Teddington, holds Open Days highlighting the activities of one of its three research groups. This year it is the turn of the Engineering Sciences Group, and its work will be on show on May 9, 10 and 11. Below we give an outline of the functions and work of the Group's divisions. Some aspects of the work to be featured at the Open Days are illustrated on the following three pages.

The **Engineering Sciences Group** has four divisions: the Division of Computer Science, the Division of Numerical Analysis and Computing, Ship Division and the Division of Maritime Science. As the names of its divisions suggest, the Group is oriented towards activities associated with specific industries, and its work has direct links with the design and operation of ships, with computer usage, with engineering fluid dynamics and with acoustics. Each division stands as an independent unit, but as a Group the four complement and reinforce each other, and there are, of course, particularly close ties between the two computing divisions and between Ship and Maritime Science.

The overall aim of the **Division of Computer Science** is to extend the application of computers and information technology, especially by facilitating communication between the user and the computer; and it fulfils this aim by research to develop improved or new systems of hardware and software. Its scope can perhaps be best indicated here by citing some examples.

The method of man/computer interaction used for a given application, for instance, depends on the choice of terminal, and on such factors as the language, protocol, format and speed of response employed. The Division is studying working systems and conducting laboratory experiments with the aim of gaining a better understanding of this interaction and giving guidance to the designer. In the same context, computer technology has now advanced to the stage where computers can be programmed and operated by people with little or no specialist training, and the Division is conducting work aimed at accelerating this trend. Flexible hard- and software have been assembled for use in man/computer interaction experiments, and computer applications being studied include medical-history taking, job training, graphic design in architecture, and personality and aptitude testing. Already developed is a software system which will enable the Metropolitan Police to store facts on criminal activities, and to interrogate the store in a language which, though restricted, can be used with little training.

Essential to communication are the long-distance links which connect a computer with the user or with another computer. The Division has been studying the problems involved in such data-communication links for some four years, and has designed a versatile system, called *packet switching*, which overcomes many of the limitations of conventional telephone-line links. The Division has used packet switching to build, for NPL's own data-communication purposes, a model network incorporating an independent file store system accessible from any of the Laboratory's numerous small computers.

The Division is also a pioneer in the field of pattern recognition. Machines and programs produced for reading badly printed numbers have now been taken up commercially, and one capable of reading handwritten numbers is nearing completion. Work on computer communication by means of speech is under way.

Finally, the Division is responsible for the technical management of the DTI *Advanced Computer Technology Project*—co-ordinated research undertaken by firms manufacturing computers, peripherals and other major computer components.

The **Division of Numerical Analysis and Computing** has a dual aim: in its numerical-analysis work it is concerned with the assessment of existing, and the development of new, methods for the numerical solution of mathematical problems arising in science, engineering and commerce; and in its computing role it promotes the efficient use of computers by improving compilers and operating systems and exploiting existing and new equipment. Inasmuch as its work involves assessment of methods and equipment, and the dissemination of information about them, the Division could be regarded as producing 'standards' for actual and potential customers. It also, however, has the domestic responsibility of providing a computing service throughout the Laboratory, via a number of remote-access terminals and by 'batch-processing' large problems.

The Division concentrates on the development of programs designed to be both of wide applicability and of guaranteed performance and reliability. At the Open Days this emphasis will be illustrated in relation to such aspects as linear algebra, in which the structure of any particular problem requires the choice of an appropriate algorithm; optimisation, including the solution of linear and quadratic programs and general unconstrained and constrained problems; data approximation requiring acceptably close and smooth mathematical representations of physical data; and differential and integral equations relating to a wide range of practical problems.

Other work to be illustrated by the Division includes the NPL *Graphical Output Scheme*, which provides comprehensive facilities for displaying experimental and computed results visually in a uniform way; the measurement of software performance (demonstrated on the basis of results derived from a comparative study of the performance of Algol compilers on a large number of computers); and the computer manipulation of text, a development which the Division has applied to computer programs (to generate a logically structured and annotated text) and to report preparation.

Ship Division's research is aimed at increasing ship efficiency and safety. The Division carries out work both for the Government and for the ship-operating and shipbuilding industries. Its primary function, however, is to serve the Government, by, for example, furnishing the scientific background information necessary for framing legislation, and by providing information and advice on ship hydrodynamics and other matters affecting marine safety requirements. Safety and performance are interrelated (for, after all, any improvement in, say, a ship's steering or seakeeping must make for greater safety in addition to increasing efficiency), but by and large the Division's work for the Government is directed primarily towards increasing safety, and that for industry principally towards optimising a ship's performance. As much as a third of the Division's staff is employed on work commissioned by industry. Why? Firstly, because ship-model experimentation demands massive capital equipment, far too costly and complex for most firms to afford and maintain. Secondly, because close contact with industry enables the Division's research programme to be related closely to real needs.

Ship Division has some of the best equipped and most modern ship-model facilities in the world. At its main base at Feltham it has a 400-m towing tank incorporating a wavemaker and a carriage capable of speeds up to 15 m/sec; a square tank for seakeeping and manoeuvring experiments; two variable-pressure water tunnels; a circulating-water channel equipped for detailed flow and pressure measurements; and a variety of smaller test rigs. At Teddington two older towing tanks are also in regular use. Much of British merchant-ship construction is based on hull designs developed by NPL.

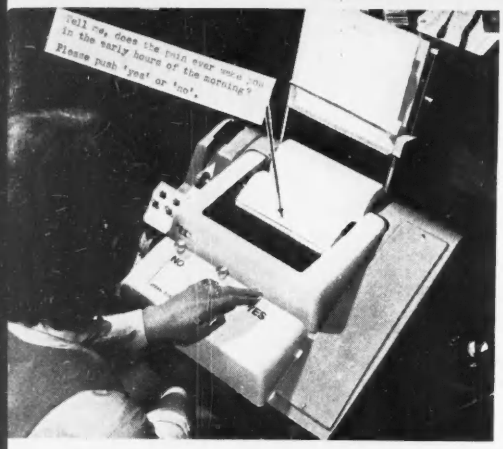
The activities of the Division can be grouped broadly as follows: hull resistance in calm water and in waves; propulsion devices; hull vibration induced by propellers and by waves; ship motions caused by waves; manoeuvring; and design studies for new ships. Within these broad limits the Division is conducting work on such aspects as: the factors influencing propeller efficiency and the propeller/hull interaction; the development of ducted propellers; methods of minimising loss of speed, wetness and slamming in head seas; the reduction of rolling; the damping of wave-induced hull vibration; methods of improving the effectiveness of a ship's rudder; and the behaviour of large ships in shallow water.

The **Division of Maritime Science**—formed in April 1971, and hence the youngest of the Group's divisions—is concerned with studies of marine traffic, marine vehicles (including high-speed craft of unorthodox type), engineering fluid dynamics, acoustics and the development of data-acquisition and data-analysis systems. Examples of these facets of the Division's work will be on display at the Open Days.

Maritime Science's studies of marine traffic are carried out primarily to provide support for the legislative and certification functions of the Government departments involved with safety at sea. Typical of such surveys is that which the Division has been carrying out, by radar and other methods, to establish data on the density, type and distribution of marine traffic in the Dover Straits. Also in progress are investigations into the circumstances of shipping casualties and the carriage of hazardous cargoes. At Hythe, Southampton, the Division has comprehensive facilities for conducting sea trials on ships, marine craft and marine structures.

The Division's work on engineering fluid dynamics includes research into the effects of fluid flow on vessels and civil-engineering structures close to the earth's surface, and into the fundamental nature of the flow around such bluff bodies. A range of research facilities is available, and the studies include wind-tunnel tests on models of ships, buildings and civil-engineering structures generally.

Maritime Science's Acoustics Section carries out research into hearing, the effects of noise on man, and the physics of sound propagation. It also conducts acoustical measurements related partly to noise problems and partly to the precise calibration of electro-acoustic transducers and the performance of the facilities used for such measurements.



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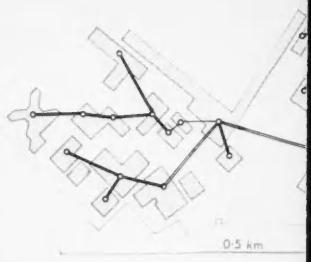

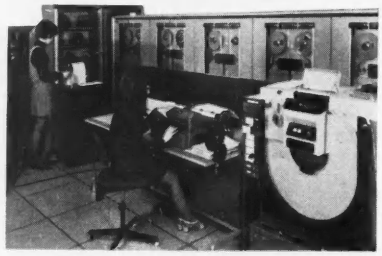

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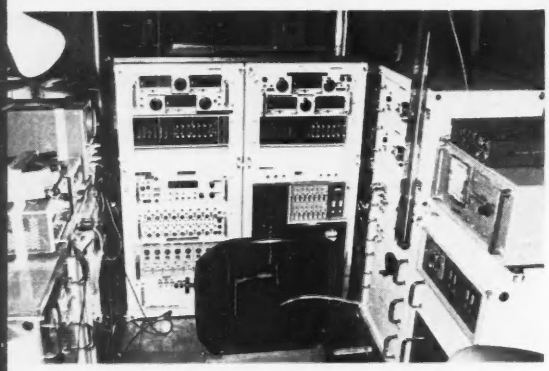

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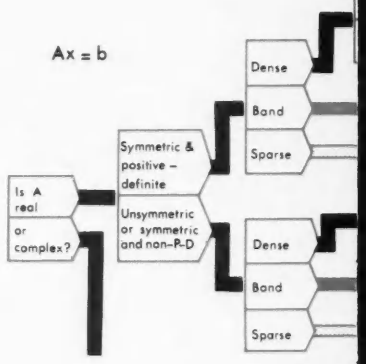

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1 At the Southern General Hospital, Glasgow, out-patients of the Gastro-enterology Department have been routinely interrogated by a simple modified computer terminal. Patients describe the computer as 'friendly' and 'very' understandable', and some say they even prefer it to a doctor! The system and the automatic history-taking program were developed by Computer Science Division.

2 Computer Science Division has designed and constructed a data-communication network interconnecting NPL's computer service and a variety of data terminals, small computers and special services. The illustration shows the cable layout and some of the units connected.

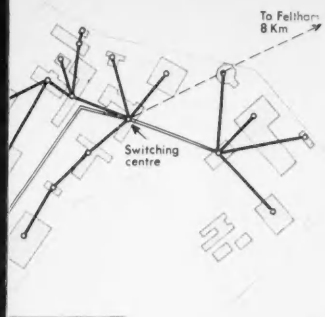
Based on the 'packet-switching' principle proposed by NPL for a national system, the network handles 'addressed bytes' in 3 levels of multiplexing. It thus enables some advanced ideas in data communication to be tested in practice.

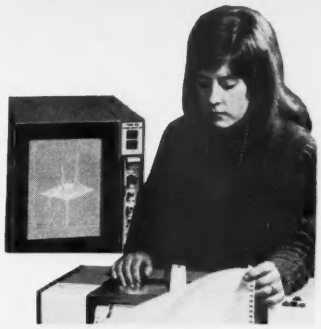
3 *Character recognition.* Computer Science's CHIT system provides an effective means of capturing data at source (ie, as it is written), in a manner sympathetic to the non-professional user. No special writing instrument is required, and 'hard copy' is produced simply by writing with pen on paper.

4 Speech is man's most effective means of communication, and interactive experiments have demonstrated that a speech input to a computer would be acceptable, and often more efficient than using a keyboard. The picture shows the system on which Computer Science Division has developed methods of detecting speech features for recognition of words and phrases.

5 Collaboration between BOAC, Rolls-Royce and NPL's Division of Numerical Analysis and Computing has led to the development of improved light-weight structures for aircraft floors. A carbon-fibre sandwich-type floor panel selected for a heavy-duty floor area in 747 aircraft can be seen in the picture.

6 NPL's *Graphical Output Scheme* enables programmers to present results in visual form. The two drawings exemplify different treatments of three-dimensional information.





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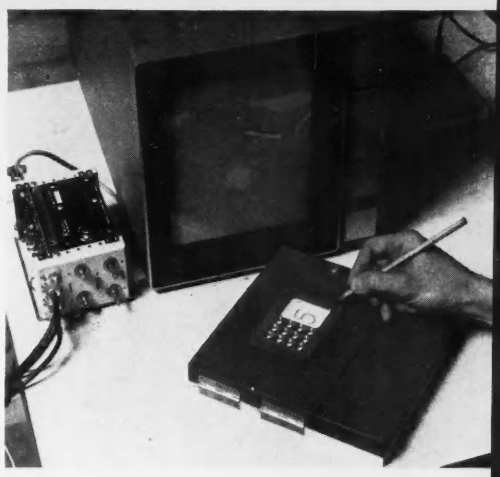

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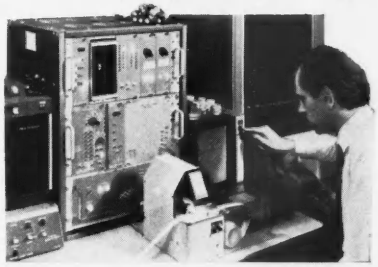

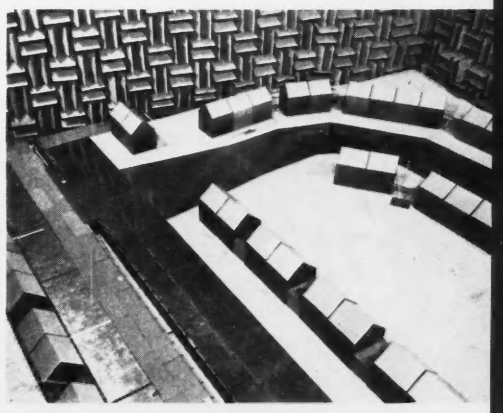

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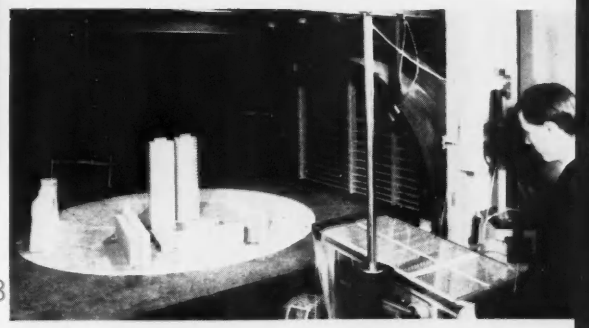

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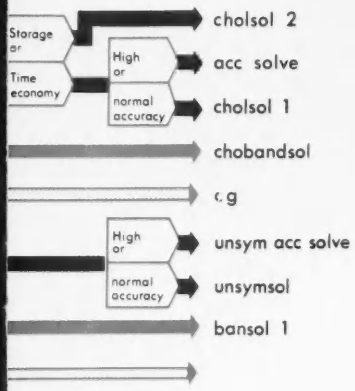

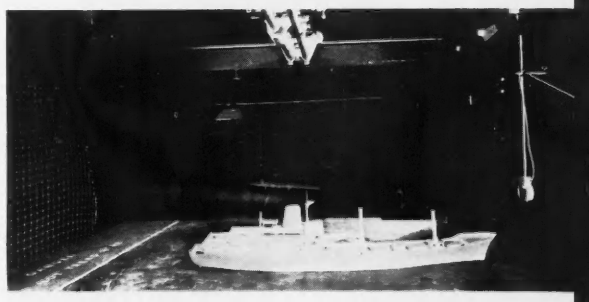

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7 Linear algebra lies at the heart of many numerical processes, and has been extensively studied in the Division of Numerical Analysis and Computing. The diagram shows how the best algorithm may be chosen for the solution of a set of linear equations.

8 Stress analyses on hooks, eyebolts and shackles by the Division of Numerical Analysis and Computing have been used in the preparation of national and international standards for lifting gear.

9 Designed to be adaptable to a variety of situations, the Division of Maritime Science's *Seaborne Instrumentation System* provides accurate data on craft performance in severe environments. The photograph is of a typical SIS installation.

10 Typical of the trials in which the Seaborne Instrumentation System plays a vital role are those to which this side-wall hovercraft is being subjected.

11 *Ultrasonic flowmeter.* Maritime Science has developed this simple method of measuring the rate of volume flow in an air duct. Based upon the downstream convection of an ultrasonic beam projected across the flow, the device requires no calibration, has a high frequency reponse and does not obstruct the flow.

12 Using model techniques, and a room with walls minimising reflection of high-frequency sound, Maritime Science's Acoustics Section investigates traffic-noise levels at a wide range of sites, varying from open grassland to heavily built-up areas. The model shown represents a section of a trunk road and adjacent housing.

13 Maritime Science measures pressure distributions over model buildings in an open jet wind tunnel.

14 Smoke dispersal from a ship's funnel being investigated in an open jet wind tunnel.

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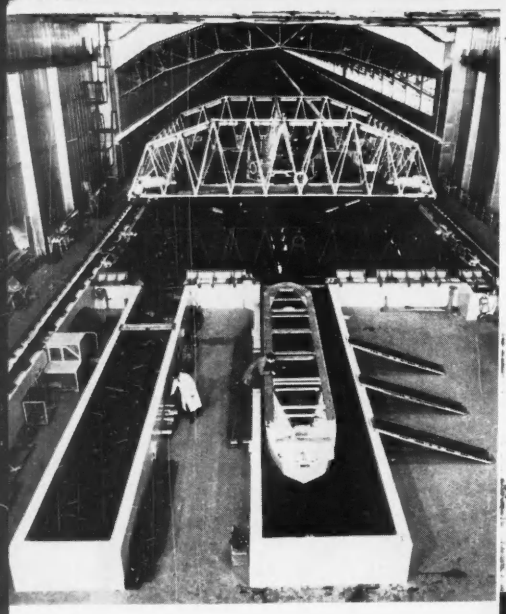

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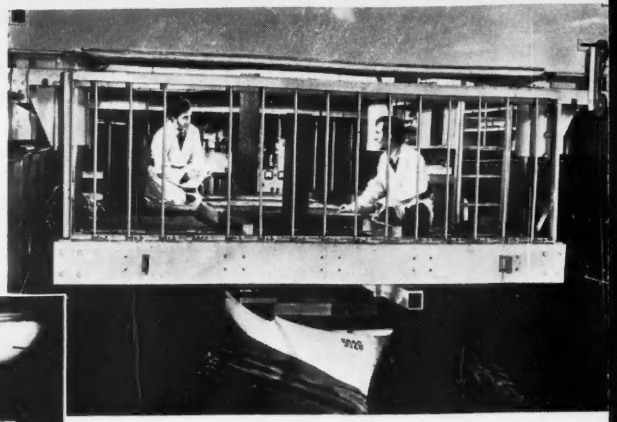

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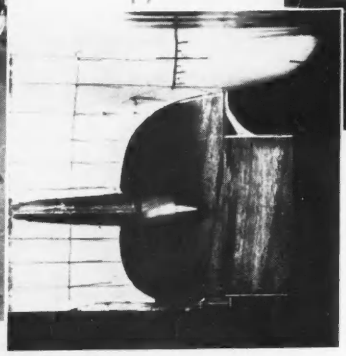

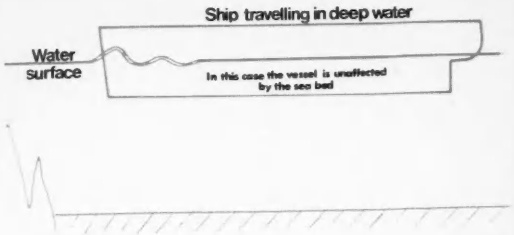

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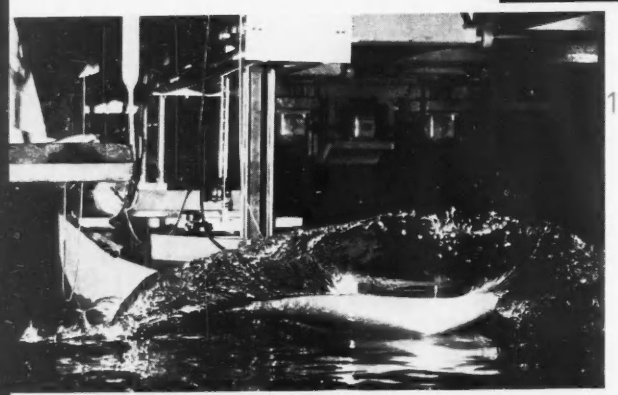

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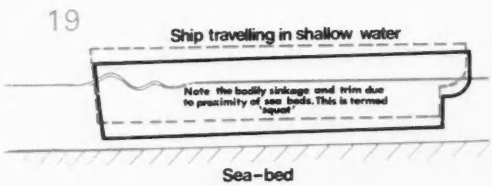
Ship travelling in shallow water
Note the bodily sinkage and trim due to proximity of sea beds. This is termed 'squat'
Sea-bed

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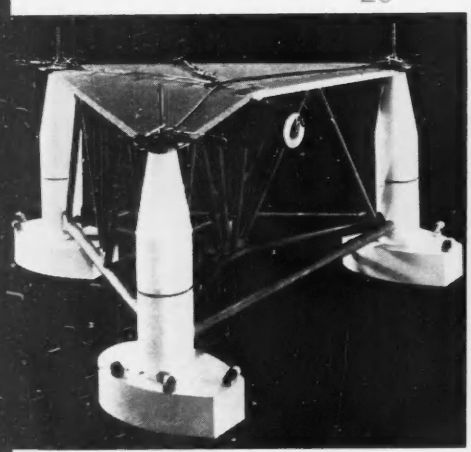

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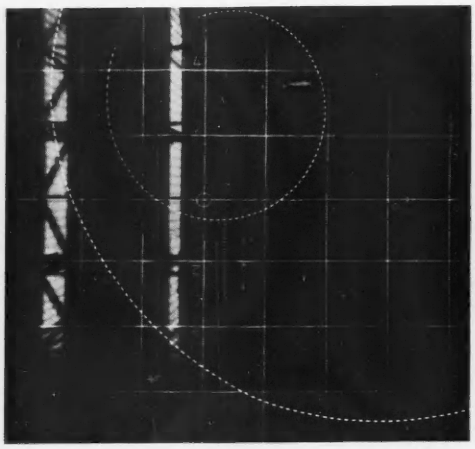

15 Model of a very large tanker being prepared for towing tests in Ship Division's long tank at Feltham. Determining the optimum shape of such vessels forms an important part of the Division's work.

16 Model of a fast cargo ship under test in Ship Division's circulating-water channel. Flow conditions over the hull can be observed by means of an underwater television camera or through side windows in the test section.

17 View of the stern of a model under test in the circulating-water channel. Study of stern flow can throw light on some causes of ship vibration.

18 Seakeeping tests on a container-ship model in head waves. The bow is of a shape designed to throw water clear of the forecastle deck.

19 Shallow water affects the behaviour of ships in several ways. Their turning performance, for example, is impaired, and, as illustrated here, they settle down bodily in the water, so increasing the risk of grounding. This type of navigational problem is being studied by Ship Division.

20 A model of a semi-submersible drilling platform used to investigate the motions of the prototype, and the forces present in its mooring system, under North Sea wave conditions.

21 Several devices for improving the stopping and turning ability of ships have been model-tested by Ship Division. Of these, the rotating-cylinder rudder offers particular promise, and is soon to be tested in full-scale trials. Its effect on the turning ability of a ship model can be seen from the superimposed multi-exposure photographs shown here. They were taken from a point above the manoeuvring basin, and record the track of a light source located on a radio-controlled model. The much smaller turning circle is that of the model under operation of the rotating-cylinder rudder.

22 The main structure of very large ships can be vibrated at resonance by ocean waves. To combat this new problem, Ship Division has invented a hydraulic vibration damper—shown here under model test.

news

Marine technology policy—a step forward

THE creation of a Marine Technology Requirements Board to help identify opportunities for the industrial and technical exploitation of the resources of the sea and seabed was announced on March 20 in Parliament by Mr. Frederick Corfield, Minister for Aerospace. Mr. Corfield said: 'By marine technology we mean those industrial and technical activities which are necessary to the commercial exploitation of the resources of the sea and the seabed other than fish; but not the scientific aspects, commonly understood to be included in the term "oceanography".

'It is widely agreed that the UK's marine and maritime interests are both important and expanding. The exploitation of hydrocarbons in the North Sea is a very obvious example but there are many others. These developments present new opportunities for British technology in this field which are, in general, appreciated by industry but which for various reasons are difficult to exploit.

'For these reasons the Government thinks it right to initiate and finance feasibility studies and other preliminary investigations in the closest co-operation with industry to help to identify where these opportunities may lie and what is needed.

'Interdepartmental co-ordination in this field, wherever it is not already carried out through long established arrangements, lies in the hands of the Committee on Marine Technology. This Committee has done a good job in the initial identification of commercial opportunities and as a direct result of its work the Department of Trade and Industry, on behalf of the Committee, has been able, in the last two years, to put in hand about £1,000,000 worth of work, half of the cost of which has been provided by industry and other customers. Nevertheless, it has become clear that the Committee's work has been circumscribed by its terms of reference.

'The Advisory Committee on Marine Technology will therefore be replaced by a Marine Technology Requirements Board which will identify customer requirements for research and development and help formulate relevant Government programmes. The Marine Technology Requirements Board will report in future to the Secretary of State for Trade and Industry, and, as a result of these changes have greater status and authority. Experts from industry, official and non-official bodies will serve on or be available to the Board so that the best advice can be available on which to stimulate new initiatives by Government and industry in this field.'

This announcement of policy in the field of marine technology marks a step forward in this important area.

Four main markets at present envisaged in marine technology are:

- Techniques and equipments for the recovery of oil and gas from beneath the sea;
- Systems and equipments for the navigation and operation of ships;
- Techniques, systems and equipments for underwater civil engineering;
- Fishing systems and fishing product processing equipment.

Future markets in marine mining and activities at depths greater than the continental shelf will also be important, but not for some years.

As part of the continuing process of identifying the research and development needs of industry the Committee on Marine Technology's new publication *Research and Development in Marine Technology* will be discussed in May at a seminar organised by the Society for Underwater Technology, the Underwater Engineering Group of CIRIA (Construction Industry Research and Information Association) and the Association of British Oceanology Industries Ltd., in association with the DTI. This occasion will provide another opportunity for industry to outline its technological requirements.

The Marine Technology Requirements Board is one of a number of such Boards, aimed at identifying the 'customer-contractor' balance in DTI's R & D activities, to which the Department referred in its memorandum to the Select Committee on Science and Technology on March 15.

Computer-aided design conference

THE second international conference on *Computer-aided design*, is to be held at Southampton University from April 25-28. The papers to be presented represent a great deal of exploratory work during the past three years in both application programmes and the general-purpose software which supports them. Many of the papers come from industrial organisations fully conscious of the economic aspects involved. The main part of the conference will be preceded by tutorial sessions on April 24-25, which are open to a limited number of conference participants at an extra fee. There will be a general appreciation course, consisting mainly of lectures and discussion, which is designed for the engineer who wishes to be brought up to date rapidly on CAD techniques and application areas.

The conference is organised by the Institution of Electrical Engineers and the Electronic Engineering Association.

Provisional programmes and registration forms are available for all conferences from the Manager, Conference Department, IEE, Savoy Place, London WC2.

Torry transferred to MAFF

THE Torry Research Station is being transferred on April 1 from the Department of Trade and Industry to the Ministry of Agriculture, Fisheries and Food, and a Controller of Fisheries Research and Development has been appointed. Announcing the transfer in the Commons, Mr. James Prior, Minister of Agriculture, said:

'On December 17, 1970, I informed the House that my right hon. Friends and I who are concerned with the matter had initiated a review of the organisation of Government-aided fishery research and development. In the light of this review we have reached the conclusion that certain changes of organisation are desirable.

'First, it is proposed from April 1 next, to transfer responsibility for the Torry Research Station, whose main function is the study of fish as a food, from the Secretary of State for Trade and Industry to me. In assuming this responsibility I shall maintain the closest association with the Secretary of State for Scotland and the Secretary of State for Trade and Industry so that their interests are fully taken into account.

'Second, the interests of the Government and the industry as "customers" for fisheries research and development are to be brought together and exercised through a Fisheries Research and Development Board. The Board's primary task will be to advise both Fisheries Ministers on the objectives of fisheries research and development, to agree the programmes needed to meet these objectives (including priorities within them) and the necessary financial resources, and to monitor progress. The Board will be representative of the Government Departments concerned, and of the National Environment Research Council; and I hope that the industry too will agree to be represented.

'Third, it is intended to appoint a Controller of Fisheries Research and Development, whose task it will be to supervise the research and development programmes of the various laboratories and stations and to ensure that they are met in the most efficient and economic way possible. The Controller will be one of the present Directors of Government fisheries laboratories; he will be responsible for the work of the laboratories and will report to my right hon. Friend the Secretary of State for Scotland and myself jointly.

'The Controller of Fisheries Research and Development will be supported by a management group of Directors of the Government fisheries laboratories, of which he will be chairman. The chief function of the group will be to control and ensure co-ordination of the work of the laboratories and stations and to eliminate the possibility of unnecessary duplication. I am confident that these measures will do much to ensure that the needs of Government and industry alike as customers for research and development in the fisheries area will be identified, understood and carried out with efficiency and economy.'

Designated Controller of Fisheries Research and Development from April 1 is Dr. H. A. Cole, Director of Marine Research at the Sea Fisheries Laboratory at Lowestoft. He will retain the Lowestoft post.

Symposium on terotechnology

THE Duke of Edinburgh, who is President of the Council of Engineering Institutions, is to open a Symposium on Terotechnology at the London Headquarters of the Institution of Mechanical Engineers on Wednesday, May 24, 1972. Arranged by the Institution of Plant Engineers and the Institution of Mechanical Engineers, in conjunction with the Department of Trade and Industry Committee on Terotechnology and the Council of Engineering Institutions, the Symposium will provide a forum for discussion of the role of professional bodies in terotechnology, and some 50 professional institutions and societies are expected to send delegates. Papers will be presented by eminent speakers from industry and Government.

Warren Spring Laboratory review

ASPECTS of industrial and environmental research carried out at the Department of Trade and Industry's Warren Spring Laboratory are reported in the Laboratory's illustrated annual review. New industrial developments touched upon include a new type of mixer for heavy pastes; a pneumatic pipeline system for an asbestos slurry; a submersible sensing device for determining elements in slurries in a process stream; and a method for recovering copper, tin and zinc from discard slags. Copies of the review are obtainable free on application to: Warren Spring Laboratory, PO Box 20, Gunnels Wood Road, Stevenage, Herts SG1 2BX.

BSI standards conference

Bsi's 1972 standards conference will be held on May 12 at Hampden House, 61 Green Street, London, W1. A full programme of talks and discussion will treat two themes: *The economic benefits of standardization* and *The use of standards in the industrial environment*. Lord Sherfield, president of BSI, will open the conference. The morning will be taken up with a lecture on the economics of standardisation from a theoretical standpoint and by practical examples of savings through standardisation in mechanical engineering and electrical engineering. In the afternoon speakers will show how standards effect the industrial environment.

Fee for the conference is £8, or £6 for members of BSI's Standards Association Section which is responsible for organising the conference. Programmes and application forms may be obtained from the Secretary, Standards Associates Section, British Standards Institution, 2 Park Street, London, W1A 2BS.

Design and manufacture of heat pipes

A THREE-DAY course on the *Design and manufacture of heat pipes* will be held on April 11-13, at the Birniehill Institute, East Kilbride. Originally developed for space applications, the heat pipe is finding increasing acceptance by a variety of industries for use both in the production process and in the product. NEL is running this intensive three-day course aimed at giving an understanding of the characteristics of heat pipes as well as a design and manufacturing capability. The course will comprise lectures and demonstrations. The lecturers will be from NEL and industry. Details from the Course Organiser, Birniehill Institute, National Engineering Laboratory, East Kilbride, Glasgow. Tel. East Kilbride 20222, ext. 570.

Groundwater pollution conference

A WORKING conference on groundwater pollution is to be held by the Water Research Association at Reading University from September 25-27. Information on groundwater quality and its protection is widely scattered, and the biological, chemical, engineering, hydrological and legal aspects will be brought together at this conference, which will provide a general framework of scientific principle and management practice to set the scene for a number of case histories of groundwater pollution. These will principally be drawn from British waterworks experience and will be grouped under three main headings, prevention, detection and cure, each being prefaced by a review paper. Solid as well as liquid sources of pollution will be discussed and one session will be reserved for consideration of the problem of borehole clogging. Programmes and details: The Water Research Association, Medmenham, Marlow, Buckinghamshire, SL7 2HD, England. Tel: 282 (049 166 282).

First legal metrology translation

THE Department of Trade and Industry has published the English translation of International Recommendation No. 1 of the International Organisation of Legal Metrology (OIML), which deals with Cylindrical Weights from 1 g to 10 kg (Medium Accuracy Class). The Recommendation describes the nominal values, shapes, markings, dimensions and other details of cylindrical weights. International Recommendation No. 1 may be purchased from the Technology Reports Centre, Department of Trade and Industry, Station Square House, St. Mary Cray, Orpington, Kent, for 90p.

HOW TO SUBSCRIBE TO *NEW TECHNOLOGY*

There are two ways in which readers can arrange to receive the *New Technology* supplement regularly: *Either* by taking out a full annual subscription to *Trade and Industry* at £7.60 (including postage).

Or by subscribing to the 12 issues of *Trade and Industry* per year which contain *New Technology* at £1.75 (including postage).

Subscriptions to: HMSO, PO Box 569, London SE1.

Standards of radioactivity to be issued in 1972

THE National Physical Laboratory issues standards of radioactivity which are of interest in industrial and medical applications of radioactivity. In order to achieve the highest accuracy, delivery of the radioactive solution is made prior to the reference date so that recipients can make their measurements at approximately the same time as the absolute measurements are made at NPL. The list of radionuclides for 1972 includes for the first time a radionuclide standard which will be purified by means of a mass separator. Under normal circumstances Co-58 is contaminated with about 0.5 per cent of the long lived isotope Co-60 but by using the NPL electromagnetic mass separator the purity of the issued activity will be better than 99.99 per cent. The radionuclides are tabulated below.

These standards, except the Kr-85, will consist of weighed quantities of radioactive solution, approximately 1 gr., contained in 2 ml. ampoules. The cost, excluding air freight, is £15 per standard except for those marked with an asterisk for which the cost is £20.

Information about other services in this and related fields is contained in a booklet *Measurement Services: Radiation Science* available free of charge. Both the booklet and order forms are available from the Division of Radiation Science, National Physical Laboratory, Teddington, Middlesex TW11 0LW.

Radio nuclide	Nominal activity	Particulars	Month of issue
Ga-67	200μCi	Gallium chloride in 0.1N HCl	March*
Kr-85	1mCi	Krypton gas in break seal ampoule	April
Pm-147	100μCi	Lanthanum chloride as carrier in 0.1N HCl	May
Nb-95	100μCi	Niobium oxalate complex in 1N oxalic acid	June
Be-7	100μCi	Beryllium chloride in 0.1N HCl	September
Co-58	100μCi	Cobaltous nitrate in 0.1N HNO_3 (Isotopically enriched to a Co-58 radionuclidic purity of better than 99.9%)	October*
I-125	200μCi	Potassium iodide in neutral solution	November
C-14	5μCi	Tartaric acid (1,4-C14) in 2% ethanol/water solution	December

High-definition radiography

THE Nondestructive Testing Centre, Harwell, has developed a high-definition X-ray unit which resolves extremely fine microstructural detail and extends the applications of radiography in industry, medicine and biology. Its fine focal spot enables a projection technique to be used for small areas of a specimen to give enlargements of up to ×10 magnification, while large areas can be examined by contact radiography; the minute size (15 microns diameter) of the focal spot ensures that structures anywhere within the area under examination are recorded with equal clarity. Because film and specimen can be separated, stereo-viewing techniques can be used and sectional radiographs (laminographs, tomographs) of complex structures and time sequence radiographs of slowly changing structure detail can be produced. When linked to a suitable image intensifier, internal modification, due to high speed events can be followed on a television screen. Typical examples of the application of this microfocus unit include: inspection of integrated microcircuitry and transistors; studies of cable insulation; examination of microwelds, thin-section electron beam welds and mechanical fastenings; precision radiography of light alloy sections and thin steel sections; analysis of cavitation, pore and void formation in metals with a resolution capability of 10 microns; distribution of microinclusions and contaminants in low density materials; study of plastic and enamel coatings; inspection of thermocouples; bone and tooth studies; locating contamination of food products; diagnostic study of microcirculatory patterns of abnormalities in human tissue and organs; forensic comparison of small samples; botanical studies of wood and plant tissues; and fine-scale study of entomological features.

Materials handling film catalogue

THE National Materials Handling Centre has published an up-to-date catalogue of films in materials handling and related topics. Over 170 films are included, each entry giving title, details of availability, technical information and a synopsis of the film. Also included are a subject index and an index to organisations supplying films. The catalogue is available at £1 from the National Materials Handling Centre, Cranfield Institute of Technology, Cranfield, Bedford.

Fluid-sealing techniques

A COMPREHENSIVE introduction to fluid-sealing techniques for all users of seals is the aim of a two-day course being organised by BHRA Fluid Engineering, the centre for research, development and testing of fluid seals. The course will be held at Cranfield, Bedford on May 3-4, and is intended for equipment designers, plant and maintenance engineers, and design draughtsmen. Topics to be covered include seal types and selection, sealing materials, seal-failure analysis and seal economics. Time will be available for informal discussion of delegates' problems. Lectures will be given by BHRA staff and lecture notes will be provided for permanent reference. Full details and registration forms may be obtained from: Course Organiser, Fluid Sealing Techniques, BHRA Fluid Engineering, Cranfield, Bedford.

More information: Where possible, items in *New Technology* indicate the best sources of further information. Readers are advised also to seek information on matters relating to *New Technology* from the following DTI regional offices: Edinburgh 031-225 1822; Cardiff 62131; Newcastle upon Tyne 27575; Manchester, 061-832 9111; Leeds 38232; Nottingham 46121; Birmingham, 021-643 8221; Bristol 21071; London and South East, 01-684 9781; Eastern, 01-828 4355. In Northern Ireland, information is given by the Dept. of Industrial and Forensic Science, Belfast 21722.

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